Enabling automotive design innovation for emerging composite manufacturing

Automotive engineers are investigating the use of composite materials for everything from chassis and frames to powertrains, gears, and interiors. The payoff could be huge, but without specialized software, the dream may not come true.

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The relentless pursuit of innovation drives automotive engineering. And today, more than ever before, engineers are investigating new processes and non-metallic materials which will lead to adventurous designs and manufacturing innovations. For example, Formula One and Le Mans teams have used carbon fibre instead of metals as a primary material for their racing car structures for many years. Now, carbon fibre is also being considered for medium-volume production of structural automotive parts for frames, chassis and exterior panels.

In fact, automotive companies have already begun incorporating major structural carbon-fibre components in some specialty models - ones with annual output below 1,000-1,500 units. Carbon fibre is used in supercars such as the Mercedes SLR McLaren, Ferrari, Aston Martin or Bugatti. More recently, the GT category and some limited editions such as the Ford GT, Porsche Carrera GT, and BMW M3 CSL have incorporated carbon-fibre components.

And, while highly engineered materials are making their way into car structures, other new technologies involving engineered textiles and plastics are being used increasingly in automotive interiors. Seat systems in particular have become very complex, involving layers of soft goods and injected foam, assembled with mechanical and electronic components. Interiors and seat systems have become highly complex engineered assemblies with specific engineering challenges to solve.

While the use of composites and some advanced design technology is not readily applicable to mass production yet, a "trickle-down" effect is indeed reaching higher-volume production cars and is being accelerated by various governmental and private research and development efforts such as USCAR/ACC, TECABS, Hypercar or the Aero-Stable car. Concurrently, economic factors including rising fuel costs, higher steel prices, a demand for customization and lower investment costs are all increasing the general interest for structural composites.

So, what are the real obstacles to a more rapid industry change in favour of composites? The experts will call out obstacles such as material cost and manufacturing cycle time, but more important challenges include the lack of design experience, unproven manufacturing methods, and the absence of reliable predictive tools. Above all, it has become clear that new materials and processes cannot win the business case unless a combination of benefits is achieved, not just a price point or weight savings.

In this context, CAD-integrated specialized engineering software holds the key to more efficient and robust innovation. Automotive engineers must be given the freedom to rapidly and confidently explore the extended design space while avoiding the structural "black metal" approach and enabling novel styling. Specialized engineering software enables manufacturers to accurately simulate new processes while rapidly providing appropriate feedback to design processes. Engineers also must be able to manage increased technological complexity while monitoring costs and conforming to industry standards and regulations for timely, error-free information sharing between teams. To solve these critical challenges, automotive manufacturers and suppliers strive to learn from the technology experience and achievements of organizations that have already used composites and apply that knowledge to today's new automotive designs.

Structural composites - From racing cars to production vehicles

Working in the deadline-driven environment of Formula One racing, the engineers of Renault F1 Team faced a daunting competitive challenge. The team needed to design and manufacture key parts of a composite race car chassis in less than six months that would meet a number of demanding weight, strength and performance specifications as well as recently-mandated impact and safety requirements. Because of the chassis' complex curvature, Renault engineers used specialized engineering software to simulate the lay-up and check for weak spots early in the design phase. If the parts were not designed and manufactured properly the first time, and did not fit together or perform to specifications, the team would loose an entire season.

Renault used software from VISTAGY at the start of the process to design the chassis parts in three-dimensional models. Renault used the design models to check for any weak points created by fibre deviation that could result from draping composite material over the complex curvature of the parts. The software helped Renault automate much of its composite manufacturing process, speeding the rate of ply lay-up by 62%. The composite chassis also met all impact and safety specifications and held up well under the physical pressures of Renault F1 Team's 2005 back-to-back victories in the FIA Formula One Drivers' and Constructors' World Championships.

Another example involves the Ford GT. When Ford engineers researched alternative designs, materials, and processes for the deck inner lid of the 2005 GT, they considered replacing a four-part aluminium assembly with a single-piece carbon-fibre/epoxy part. This would contribute to part consolidation and weight reduction. Engineers needed a design that could meet a manufacturing volume of up to 4,600 parts per year while ensuring high quality, strength, and very low weight. Unfortunately, Ford's choice of unidirectional composite tape for the part would substantially increase lay-up times and significantly slow down the manufacturing process.

To compensate for these shortcomings, Sparta Composites, one of Ford's suppliers, helped the team rethink the design and simplify several part features, such as standoffs and rain channels. Yet, even after simplification, the final part design had evolved from a smooth surface to a series of complex features requiring nearly 270 individual plies for manufacture. Sparta turned to a specialized engineering software solution from VISTAGY to quickly explore multiple manufacturing strategies and reduce the time for creating flat patterns and ply lay-up. The resulting process enabled the two companies to build a part that was strong, thin and ultra-lightweight, and could be readily and cost-effectively manufactured based on all specifications (Figure 1). At a mere six kilograms, the composite part weighed 75% less than a comparable metal component.

Realizing the promise of design innovation for commercial vehicles

For medium-to-high-volume mass-produced commercial cars, though the production specifications, processes, and requirements are quite different from highly specialized racing and sports cars, engineers must similarly explore new designs and manufacturing methods in order to demonstrate the technical and economical benefits of using composites.

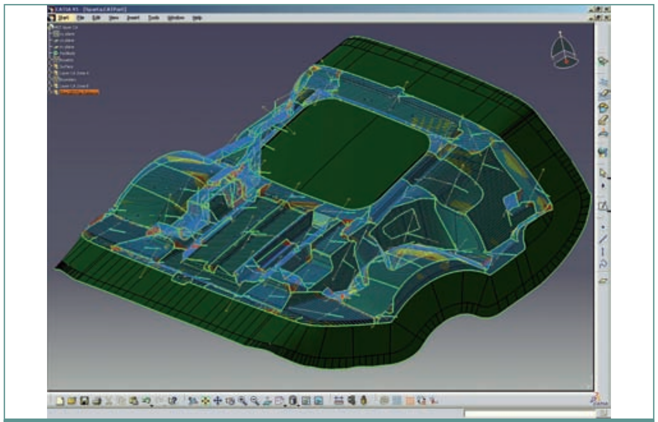

Fig. 1: Understanding fibre orientation on this Ford GT deck inner lid was of primary importance to assess part producibility in the early stages of design.

At the request of a major North American Tier 1 supplier, VISTAGY engineers recently helped study the feasibility of forming automotive body-in-white parts with a novel resin film infusion technique. One part examined by this supplier was an integrated B-pillar from a popular mid-sized sedan. Using specialized engineering software, it was possible to quickly investigate multiple design possibilities and help select the best possible configuration that would meet volume goals. The software helped simulate several material choices with varied lay-up and fibre orientations.

The simulation revealed potential weaknesses caused by fibre deformations, and previously unpredicted orientation changes due to the complex tool surface. Without this automated simulation technology used during conceptual design, the manufacturer would not have been able to demonstrate the benefits of part consolidation and would have learned about the strength and stiffness weaknesses only after much physical trial and error. Instead, rapid feedback from the software enabled a manufacturable part design that compounded multiple benefits from using composites.

Interior and seating design coming to the forefront

Other design challenges being considered by engineers include interior and seat manufacture. Commercial automotive manufacturers have come to understand that car purchases are now based heavily on the interior look and feel of the vehicle as much as on the external shape and features. Interiors and seat systems have become highly complex, engineered assemblies with specific design challenges to solve. Concurrently, interiors and seat systems in particular have become advanced engineering systems with a complex mix of textile, mechanical, electrical and electronic components. Indeed, due to the ever-increasing number of car models and interior variants, seat engineers are under much pressure to find ways to reduce "time-to-prototype", save on costs, and improve quality while meeting industry process standards and regulations.

Among seat components, the seat covers represent a particular set of issues for engineers. They must conform to a number of functional requirements including safety and aesthetics, comfort, heat, and moisture control. Integrated sensors and entertainment systems are becoming standard on many car models and new fabrics and engineered textiles are constantly being developed and used on vehicle models every year. In order to produce the required product output, trim designers must figure out complex flat patterns in order to correctly cut materials while reducing the time it takes to achieve a prototype. Also, materials used in seat covers are increasingly expensive, and the traditional development process for seat covers involves a high level of flat-pattern rework and numerous prototypes.

Engineers are constantly straddling the line between style and engineering in order to develop producible seat designs while integrating covers with other seat components including foam, suspension structures, frame and electrical components. By efficiently creating their new design using specialized software, companies can reduce material waste as well as decrease the time to prototyping, saving on the guesswork required to represent flat patterns for the seat covers (Figure 2).

A CAD-integrated specialized engineering environment also enables the various teams involved in the seat engineering process to collaborate more efficiently around a common master seat model. In this way, some of the sequential steps of the prototyping process can be eliminated in order to provide a more parallel process, hence shortening time to market. Such a specialized design environment enables engineers to quickly respond to changes in interior design demands and create completely new, innovative interior designs without the laborious manual testing and mistakes of traditional prototyping and manufacturing processes.

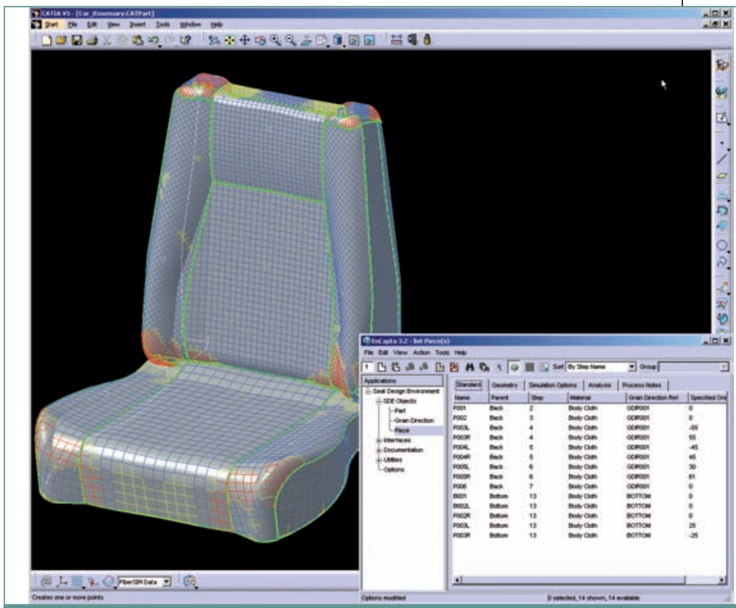

Fig. 2: The image represents a 3D seat cover conformance simulation, using VISTAGY's seat design software. Material stretch is controlled directly on the virtual model, thus greatly reducing the need for costly physical prototyping.

Conclusion

The automotive engineering industry is experiencing renewed and heightened interest in the use of composite materials. By using specialized engineering software, automotive manufacturers and their suppliers can achieve important technological innovations that generate multiple benefits from the use of composite materials. By compressing "time-to-prototype"and reducing costs while mastering added complexity, freely exploring broader design choices, and obtaining rapid feedback on design options, automotive engineers using specialized engineering software will be the ones who create strategic advantages and differentiators for their organizations constantly innovate and stay ahead of the competition. ■

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